Q1.

The density of water is 1.0 g/cm^3. If 1.0 kg of water is used to completely fill a perfectly spherical container, find the radius of the container.

A) 6.2 cm
B) 8.5 cm
C) 3.1 cm
D) 4.3 cm
E) 8.9 cm

Ans:

$$V_{sphere} = \frac{4}{3}\pi r^3 = \frac{m}{\rho_{H_2O}} = \frac{1}{10^3}$$

$$\Rightarrow r = 0.062 \text{ m} = 6.2 \text{ cm}$$

Q2.

If the acceleration *a* (in m/s^2) of a car is given by $a(t) = ct^2 + dt^4$, where the time *t* is in seconds and *c* and *d* are constants. The SI units of *c* and *d* are respectively:

A) m/s^4; m/s^6
B) m/s^2; m/s^4
C) m/s^4; m/s^2
D) ms^6 ; ms^2
E) ms^2 ; m/s^6

Ans:

$$[a] = \frac{m}{s^2} = cs^2 \Rightarrow [C] = LT^{-4}$$

$$[a] = \frac{L}{T^2} = dT^4 \Rightarrow [d] = LT^{-6}$$

Q3.

A ball of mass *m* is thrown vertically upward with an initial speed v_o. A second ball of mass *2m* is thrown vertically upward with twice the speed of the first ball. Find the ratio of the maximum height reached by the first ball to the maximum height reached by the second ball. [Ignore air resistance]

A) 1/4
B) 1/2
C) 1/3
D) 1
E) 2/3

Ans:

$$v_f^2 - v_o^2 = -2gY_{max} \Rightarrow Y_{max} = \frac{v_i^2}{2g}$$

$$\frac{(y_1)_{max}}{(y_2)_{max}} = \frac{\frac{v_1^2}{2g}}{\frac{v_2^2}{2g}} = \frac{v_1^2}{4v_1^2} = \frac{1}{4}$$

Q4.

A ball is thrown vertically upward with an initial speed of 10.0 m/s from the top of a building. The building is 50.0 m high above the ground. The time it takes the object to reach the ground is: [Ignore air resistance]

A) 4.37 s
B) 2.04 s
C) 1.02 s
D) 3.29 s
E) 5.77 s

Ans:

$$Y - Y_0 = V_0 t - \frac{1}{2}gt^2$$

$$-50 = 10\,t - 4.9t^2$$

$$4.9t^2 - 10\,t - 50 = 0 \Rightarrow t = 4.37\text{ s}$$

Q5.

A car starts from rest and accelerates at a rate of 2.0 m/s^2 in a straight line until it reaches a speed of 20 m/s. The car then slows down at a constant rate of 4.0 m/s^2 until it stops. How much time elapses (total time) from start to stop?

A) 15 s
B) 20 s
C) 10 s
D) 25 s
E) 30 s

Ans:

$$t_{tot} = t_1 + t_2 = 10\text{ s} + 5\text{ s} = 15\text{ s}$$

$$v_f = v_0 + at$$

$$t_1 = \frac{v_f}{a_1} = \frac{20}{2}$$

$$t_2 = \frac{v}{a_2} = \frac{20}{4} = 5s$$

Q6.

The position of a particle as a function of time is given by $x(t) = 4.0t^2 - 3.0t^3$, where x is in meters and t is in seconds. Its average acceleration over the interval from $t = 0$ to $t = 2.0$ s is:

A) -10 m/s^2
B) -15 m/s^2
C) -4.0 m/s^2
D) -26 m/s^2
E) 15 m/s^2

Ans:

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t} + t_2 = \frac{\vec{v}(2) - \vec{v}(0)}{2-0} = \frac{-20-0}{2-0} = -10\text{ m}/s^2$$

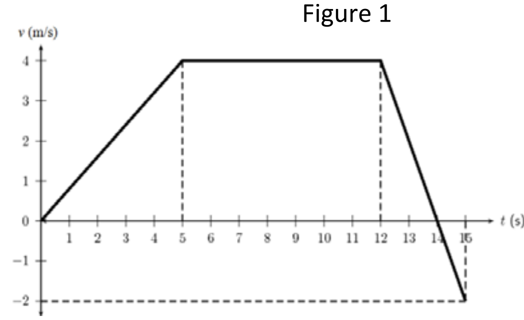
$$V(2) = 16 - 36 = -20\text{ m/s}$$

$$V(0) = 0$$

Q7.

Figure 1 shows the velocity versus time of a car moving in one dimension. Find the car's average speed over the 15.0 s time interval.

Figure 1



A) 2.87 m/s
B) 2.23 m/s
C) 2.53 m/s
D) 2.00 m/s
E) 3.02 m/s

Ans:

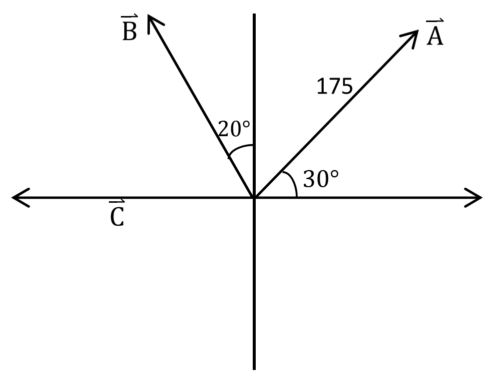
|Area under curve| = distance travelled

$$S_{avg} = \frac{43\text{ m}}{15} = 2.87\ m/s$$

Q8.

A train starts from city A and first travels to city B, located 175 km away in a direction 30.0^{o} north of east. Next, it travels for 150 km 20.0^{o} west of north, to city C. Finally, the train travels 190 km due west, to city D. Find the displacement of the train for the whole trip.

A) 245 km at 21.4^{o} West of North
B) 225 km at 59.8^{o} West of North
C) 245 km at 14.4^{o} West of North
D) 225 km at 21.4^{o} West of North
E) 245 km at 31.2^{o} West of North



Ans:

$$\vec{A} = 175\cos 30\,\hat{\imath} + 175\sin 30\,\hat{\jmath}$$

$$= 151.5\,\hat{\imath} + 87.5\,\hat{\jmath}$$

$$\vec{B} = -51.3\,\hat{\imath} + 140.95\,\hat{\jmath}$$

$$\vec{C} = -190\,\hat{\imath}$$

$$\vec{R} = \vec{A} + \vec{B} + \vec{C} = -89.7\,\hat{\imath} + 228.45\,\hat{\jmath}$$

$$|\vec{R}| = \sqrt{(89.7)^2 + (228.45)^2} = 245\text{ km}$$

Q9.

If $\vec{A} = 2.0\hat{i} + 3.0\hat{j}$, $\vec{B} = -3.0\hat{i} + 4.0\hat{j}$ and $\vec{C} = 7.0\hat{i} + 3.0\hat{j}$, find $(2\vec{A} - \vec{B}) \times \vec{C}$?

A) $7.0\hat{k}$
B) $-7.0\hat{k}$
C) $2.0\hat{i} + 1.0\hat{j}$
D) 0
E) $-6.0\hat{j}$

Ans:

$$2\vec{A} - \vec{B} = 4\hat{i} + 6\hat{j} - (-3\hat{i} + 4\hat{j}) = 7\hat{i} + 2\hat{j}$$

$$(2\vec{A} - \vec{B}) \times \vec{C} = 21\,\hat{k} - 14\hat{k} = 7\,\hat{k}$$

Q10.

Vector $\vec{A} = 7.0\hat{i} - A_y\hat{j}$ and vector $\vec{B}$ has a magnitude 6.0 units and is perpendicular to vector $\vec{A}$ and is making a 30^{O} angle with the positive x axis. If vector $\vec{B}$ is in the first quadrant, find A_y ?

A) 12 units
B) 9.0 units
C) 0
D) 6.0 units
E) 3.0 units

Ans:

$$\vec{A} = 7\hat{i} - A_y\hat{j}$$

$$\vec{B} = 6\cos 30\,\hat{i} + 6\sin 30\,\hat{j} = 5.19\hat{i} + 3.00\,\hat{j}$$

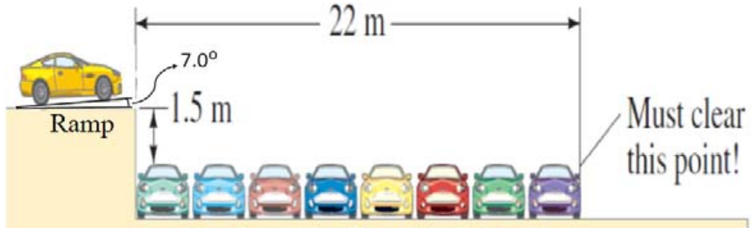
$$\vec{A}\cdot\vec{B} = 0 = (7)(5.19) - 3\,A_y$$

$$A_y = 12 \text{ units}$$

Q11.

A driver wants to make his car jump over 8 cars parked at 1.5 m below a horizontal ramp as shown in **Figure 2.** The horizontal distance he must clear without hitting any of the parked cars is 22 m. If the initial takeoff angle of the car is 7.0° above the horizontal ramp, then what should be the car's initial minimum speed so that the driver can land without hitting any of the parked cars?

Figure 2



A) 24 m/s
B) 40 m/s
C) 32 m/s
D) 20 m/s
E) 28 m/s

Ans:

$$\Delta x = 22\text{ m} = (v_0 \cos 7)t$$

$$t = \frac{22}{v_0 \cos 7} = \frac{22.2}{v_0}$$

$$\Delta y = (v_0 \sin 7)t - \frac{1}{2}gt^2$$

$$-1.5 = v_0(0.12)\left(\frac{22.2}{v_0}\right) - 4.9\left(\frac{22.2}{v_0}\right)^2$$

$$\Rightarrow v_0 = 24\text{ m/s}$$

Q12.

A particle is in uniform circular motion. Which one of the following statements is TRUE?

A) The speed of the particle is constant.
B) The velocity of the particle is constant.
C) The radial acceleration of the particle is constant.
D) The speed and radial acceleration of the particle are constant.
E) The velocity and radial acceleration of the particle are always opposite in direction.

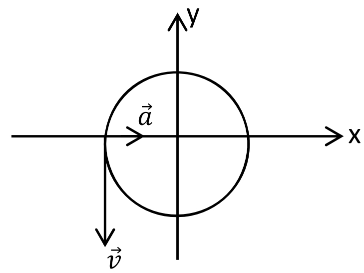
Ans:

A

Q13.

A particle is in a uniform circular motion in counter clockwise direction starting from the positive x-axis. Its period of motion is 2.1 s and the magnitude of its radial acceleration is 3.0 m/s^2. Determine the velocity of the particle when it exactly completes 1.5 revolutions.

A) $\vec{v} = -1.0\hat{j}$ m/s
B) $\vec{v} = 3.0\hat{i}$ m/s
C) $\vec{v} = 1.0\hat{j}$ m/s
D) $\vec{v} = -3.0\hat{i}$ m/s
E) $\vec{v} = 1.5\hat{j}$ m/s



Ans:

$$a_r = 3 = \frac{v^2}{r}$$

$$T = \frac{2\pi r}{v}$$

$$\Rightarrow |v| = \frac{2\pi\,(0.335)}{T} = 1\ \mathrm{m/s}$$

$$\Rightarrow \vec{v} = -1.0\,\hat{j}\ \mathrm{m/s}$$

Q14.

Snow is falling vertically at a constant speed of 7.0 m/s. At what angle from the vertical direction do the snowflakes appear to be falling as viewed by the driver of a car travelling on a straight, level road with a speed of 16 m/s?

A) 66^o
B) 45^o
C) 13^o
D) 52^o
E) 81^o

Ans:

$$\theta = \tan^{-1}\left(\frac{16}{7}\right)$$

$$\Rightarrow \theta = 66°$$

Q15.

A bullet is fired horizontally from a gun that is 490 m above a horizontal ground. Its initial speed is 10.0 m/s (see **Figure 3**). How long does the bullet remain in air? [Ignore air resistance].

Figure 3

A) 10.0 s
B) 4.90 s
C) 20.0 s
D) 1.00 s
E) 8.00 s

Ans:

$$Y - Y_0 = \overset{0}{\cancel{v_0 t}} - \frac{1}{2} g t^2$$

$$-490 = -\frac{1}{2} g t^2$$

$$\Rightarrow t = 10 \text{ s}$$
